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# **ROBOTIC RANGE CLEARANCE COMPETITION (R2C2) COMPETITION LESSONS LEARNED**

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Reset

# **R2C2 Range Clearance Lessons Learned at AFRL**

**Air Force Research Laboratory**

**Airbase Technologies Division**

**Tyndall Air Force Base, Florida**

Force Protection Branch  
Robotics Research Team  
850-283-3725

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Introduce self.

## Overview

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- **Personnel**
- **Communication**
- **Cameras**
- **Equipment Versatility**
- **Attachment Selection**
- **Equipment Health**
- **Common User Interface**
- **Particulate Management**
- **Hydraulic Fluid**
- **Critical Component Selection**
- **Redundant Safety Radio**
- **Spares**
- **Things that can go wrong**

Introduce the overview of what the presentation will cover.

## Personnel

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- Have dedicated personnel
  - Mechanics
  - Technicians
  - Safety Personnel
  - Up to 40% of time is taken up with vehicle maintenance

See slide.

# Communications

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- Line of Site
  - May need repeaters due to topography
- Bandwidth
  - May need separate control and video radios
- Heat
  - Solar loading is a frequent failure point
- Frequency Management
  - Keep radios from stepping on each other
  - Frequencies used by installations includes frequencies used by visiting units
  - Modular Systems
  - Tunable Radios
  - FCC regulations apply

See slide.

## Cameras

- Have auto iris and gain control
- Placement
  - Operators have limited FOV so cameras can be knocked off or damaged inadvertently
  - Protection from obstacles and debris
- Day and night operations



See slide.

## Equipment Selection

- Select equipment that can use many attachments
- The more versatile a machine the better. Cheaper logistics, training and maintenance.



ARTS with Brush Cutter



Power Rake



Rotary Tiller



Cherrington Screener



FAE Mulcher



Grapple Bucket



Tree Shear



Surf Rake



Kwik-Mag

Describe the ARTS, its attachments, and how they can be used to improve range clearance.



## Attachment Selection

- Hydraulic/Electrical Power necessary to operate the attachment
  - Some may need additional power packs
  - Matching attachments to the equipment (weight / power requirements)
- Magnets are strong enough to pick up debris
- Mulchers may need teeth replacement or repair



See slide.

## Attachment Selection

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### Barber Surf Rake

- Able to pick up small items comparable to a quarter and as large as a coffee can with a weight of 10lbs or less.
- Anything larger destroys tines and could jam machine
- Excellent for open areas with minimal vegetation



See slide.

## Attachment Selection

### Harley Rock Picker

- Able to pick up small items comparable to a quarter based on screen size and as large as a 155mm.
- Replaceable screens for size control cleaner scrap piles
- Excellent for open areas with minimal vegetation
- No longer in production



See slide.

## Attachment Selection

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### **FAE Mulcher**

- Cots system that was designed with flail hammers
- AFRL modified to have solid replaceable teeth
- Good for mulching 4" trees and under growth
- Leaves good mulch with minimal stumps and branches



See slide.

## Equipment Health

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- Have sensors on board to monitor critical items. Operators only know what the user interface tells them.
  - Hydraulic fluid levels
  - Engine operating data
    - Oil pressure
    - Oil temperature
    - Coolant temperature
  - Fuel Levels
  - Electrical load

See slide.

## Particulate Management

- Fine particle and dust will get into your gear.  
Add filters to inlet and outlet ports.



See slide.

## Fluids

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- Hydraulic Fluid
  - Get biodegradable where possible
- Coolant
  - Get biodegradable where possible
- Oils
  - Have spill kits close
- Spill cleanup
  - Must comply with all DOD and EPA regulations (check on installation Regs)

See slide.

## Critical Component Protection

**Protect antennas, cameras, e-stops, and warning lights**

**Before**



**After**



See slide.



## Things that can go wrong

- Broken hydraulic hoses
- Vehicle turnovers
- Loss of communications due to antenna failures
- Brush hog blades breaking
- Mulcher Teeth breaking
- Barbed wire entanglement
- Detonation of UXO
- Unauthorized intrusion on range during operations



See slide.

## Terrain/Soil Condition Issues

- Slopes and hills
  - Slide hazards, roll over and just plain stuck
- Type of soil
  - Sand
  - Clay
  - Rock
- Weather/rain
  - Make clay slick
  - Makes sand heavy
  - Can impact load bearing capacity



See slide.

## Subsurface Objects

- Excavator worked best for items up to 15' deep
- Excavators have also removed debris from shallow water



See slide.

## Towing Sensors

- Vehicle has proper hitch or connection point
- Vehicle has proper power take-off (PTO) points if necessary
- Vehicle can match the ideal speed for the sensor



See slide.

## Clean Debris Piles are Pretty

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**Surf Rake**



**Rock Picker**



See slide.

## Clean Scrap Piles are Pretty



Scrap Pile Start of Project



Surf Rake Scrap Piles



Scrap Pile End of Project



Rock Picker Scrap Piles

Starting process produced piles with a large amount of soil – Process was Optimized to minimize soil. Rock Picker produced cleaner piles than Surf Rake.

See slide.

## Clean Debris Piles are Pretty

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**Surf Rake**



**Rock Picker**



See slide.

## Magnet Soil Interaction

- Magnets will not affect post job EM surveys
- Magnets will affect magnetometers



See slide.



## Wrap Up

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- What you don't think will break will
- Adapt to the conditions in the field

Wrap up presentation.